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THE NON-OPTIMALITY OF OPTIMAL TRADE POLICIES: THE U.S. AUTOMOBILE INDUSTRY REVISITED, 1979-1985

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ABSTRACT

We examine the sensitivity of simple calibration models of trade in imperfectly competitive industries to changes in model specification, as well as to changes in the calibration parameters. We find that not just the magnitude, but also the sign of the optimal trade policies is very sensitive to the change in model specification. Indeed, use of policies derived from the 'wrong' model can reduce welfare from the status quo. However, the welfare gains to be obtained from application of the 'correct' model remain limited. Calibration models nonetheless provide useful estimates of firm and market behavior over time, as well as disaggregated elasticities of demand. We conclude that careful empirical work is necessary to guide model selection. For the present, the case for activist trade policy on the basis of calibration models should not be made.

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1 Introduction

A central theme of recent work on trade policy for imperfectly competitive markets has been that by precommitting to tariffs or subsidies, governments can affect firms' strategic positions, thereby shifting profits towards domestic firms.[1] Eaton and Grossman (1986) show, however, that the form of optimal trade policies depends critically on the nature of the competition between firms.[2] Hence, if such models are to be used to justify activist trade policy, it is necessary to have information not only on demand and cost conditions, but also on the nature of the competition between rival firms.

There has recently been some success in implementing these theories using calibration models. Dixit (1988) applies a calibrated model to U.S.-Japan competition in the automobile industry. He uses a conjectural variations (CV) approach to capture firm interactions, where the conjectures result from use of profit maximization equations calibrated to market data. The CV's then combine with calibrated estimates of demand to determine the optimal trade and industrial policies.

This work has generated excitement both in policy circles and among economists, as policy recommendations can be made even when only minimal data is available.[3] Richardson (1988), Srinivasan (1988) and Krugman and Helpman (1989) survey work in this area. Applied econometricians, however, look upon these models with considerable suspicion, because they appear to elicit policy recommendations out of tiny data sets and often poorly known elasticity parameters. Sensitivity analysis is typically limited to simply examining the effects of changing the parameters used in calibration.

In this paper, we explore the robustness of such models to changes in model specification itself. Since the model of Dixit (1988) is probably the most influential of these models to date, we examine how an alternative specification of this model alters the policy recommendations and welfare results of the calibration exercise. As does Dixit, we apply the model to U.S.-Japan competition in the automobile industry, expanding the years examined to the full range from 1979 to 1985. The specification we employ is richer than Dixit's in that we allow product differentiation not only between U.S. and Japanese goods, but also between goods made in each of the countries.[4]

The advantages of doing so are two-fold. First, the richer specification allows

[1] See Dixit (1988) for a survey of this literature.

[2] Optimal policy, of course, depends on what other distortions exist. See Krishna and Thursby (1988), who look at overall optimal policies using a targeting approach.

[3] Other examples of work in this area include that of Baldwin and Krugman (1988) and Venables and Smith (1987).

[4] Dixit, in contrast, assumes that goods produced within a country are perfect substitutes for one another—that a Chevrolet is the same as a Lincoln or a Pontiac. Although our specification allows for imperfect substitution between all products, the separability we impose groups together all U.S. cars and all Japanese cars. That is, our model puts a Chevy in the same group as a Cadillac, and a Civic in the same group as an Acura.

us to get estimates for the extent of product differentiation, as well as time-varying behavioral parameters for firms and consumers. Second, it allows us to ask which results from Dixit's simpler model are robust, and which are artifacts of the model specification.

The effect of the richer specification is to completely reverse the sign of the resulting optimal trade policy: we find the optimal policy to be a subsidy rather than a tax on imports. In fact, following the policies recommended by Dixit's model can result in a welfare loss if the 'true' model is as we specify. The more detailed specification also greatly affects the implicit estimates of collusion/competition between firms. Our results suggest that auto industry firms behave more competively than Bertrand oligopolists, as opposed to Dixit's finding of competition somewhere between that of Bertrand and Cournot oligopolists. Dixit's result is in part a byproduct of his assumption that firms within a nation produce a homogeneous good. With this assumption, the existence of any markup of price above marginal cost implies that behavior is more collusive than Bertrand.

On the other hand, some results are robust. For example, the effects on firms' behavior of trade policies, particularly the VER's imposed at the end of 1981, corresponds with the effects noted by Dixit. Our implicit estimates of demand cross- elasticities are also consistent with other sources. In addition, the targeting of instruments to distortions evident in Dixit's results seems to carry through. Finally, as is common with most calibrated trade models, the extent of welfare gains from optimal policies, particularly optimal trade policies alone, remains quite limited.

In Section 2, we develop the model, present the data and sources, and explain the calibration procedure. Section 3 contains our results. We examine the years from 1979 to 1985, which includes years when Voluntary Export Restraints (VER's) were in force. Krishna (1985) shows that in the presence of such restraints the behavior of firms is likely to become more collusive as foreign firms become effectively capacity constrained. The results in Dixit (1988) are consistent with this. Dixit looks at the years 1979, 1980, and 1983. The behavior he finds in 1983 appears more collusive than that in 1980. Our results in Section 3.1 similarly indicate that the VER's allowed Japanese firms to act more collusively from 1981 to 1983. After 1983, however, we find that both U.S. and Japanese firms acted less competitively than prior to the VER.

In Section 3.2 we derive the welfare function, which we then maximize to obtain the optimal tariff and production subsidy. As in Dixit (1988), we estimate optimal policies both with and without monopoly (union) labor rents. We then compare our results to Dixit's. Dixit finds that the optimal policy consists of a tariff on imports and a subsidy to domestic production. In contrast, our model indicates a subsidy on both imports and domestic production to be optimal. We suspect that this is related to our demand specification which increases the importance of consumer surplus in welfare, thereby increasing the attractiveness of import subsidies which raise consumption. In addition, competition in our model appears to be quite vigorous.[5] This tends to limit the gains from using the optimal production subsidy, as these gains are largest in the face of less competitive behavior. As does Dixit, we find that the existence of labor rents raises the optimal subsidy to production, and reduces, and in some cases reverses, the optimal import subsidy.

The final section offers some concluding comments and directions for future research. Our work indicates that there is good reason to be suspicious of the results of such simple calibration exercises. Indeed, policy-makers should be extremely cautious in the application of 'optimal' trade policies suggested by calibrated models, as the nature of the recommended policies may simply be an artifact of the model specification and calibration procedure. Since the optimal policy resulting from one model can differ dramatically from that of another model, and since use of the 'wrong' policies can actually reduce welfare, it is important to specify a flexible form which does not dictate the direction of the results. Even if the optimal policies are found and implemented, the gains from doing so are relatively limited, even without foreign retaliation. This result, that only fairly small welfare gains are to be had from optimal tariffs and subsidies, seems common to many such models.

Calibration models should thus probably not be used to determine trade and industrial policy without detailed empirical work to guide the model selection. Sufficiently well-specified, however, they prove to be a valuable tool in the analysis of imperfectly competitive industries, since many important results are not sensitive to model specification. Guidance from careful empirical work as to the correct demand and cost parametrizations to use in such calibration models is vital for them to serve as useful guides to determine trade policy.

2 A Model with Product Differentiation

We extend Dixit (1988) by allowing for product differentiation among the home and foreign firms, as opposed to Dixit's assumption that all firms in a country produce the same good. This is important since Dixit's results, which suggest that behavior lies between Cournot and Bertrand, could be a result of this assumption. With homogeneous goods and many firms, any mark-up over cost implies behavior more collusive than that of Bertrand oligopolists. The richer specification allows changes in the parametrization to affect not only the magnitude of the optimal tariff, but also the sign. In contrast, Dixit's parametrization restricts tariffs and subsidies to be positive.[6]

[5] The direction of optimal trade policy is known to be related to the extent of competition, as parametrized by the choice of the strategic variable, and thus in our model by the conjectural variations parameters. For example, in Eaton and Grossman's (1986) simple model of duopolistic competition in third party markets, a tax on exports turns out to be optimal with price competition, while a subsidy is optimal with quantity competition.

[6] In Dixit's model, welfare increases with a subsidy or a tariff from an initial position of zero tariffs and subsidies. With a well behaved welfare function this implies that the optimal

2.1 The Model

Demand arises from an aggregate consumer who receives all profits and tariff revenues, and maximizes a utility function of the form:

$$u = n_0 + U(S)$$

where n_0 is a numeraire good, and $U(S)$ is the subutility function:

$$U(S) = \beta S^{\alpha}$$

with:

$$S = \left(\left[\sum_{i=1}^{n} (x^i)^{\rho_x} \right]^{\rho/\rho_x} + \left[\sum_{i=1}^{m} (y^i)^{\rho_y} \right]^{\rho/\rho_y} \right)^{1/\rho}$$

This form allows ρ to parametrize the extent of product differentiation between U.S. goods x and Japanese goods y, while ρ_x and ρ_y parametrize substitution within home goods and within foreign goods, respectively.[7]

To best understand the form of the demand functions, think of this subutility function as a particular separable form, and think of β as a scale parameter. To derive the demand functions for the goods, think of S as the level of services produced by all new cars purchased, both domestic and foreign.

Let $S = F(X, Y)$, where X is the level of the aggregate good produced by domestic cars and Y is level of the aggregate good produced by foreign cars. $F(X, Y)$ is a constant elasticity of substitution (CES) function, so that:

$$S = (X^{\rho} + Y^{\rho})^{1/\rho}$$

The n domestic firms each produce quantity x^i, while the m foreign firms each produce y^i. The individual outputs of x^i make the aggregate good X according to the CES production function $G(\cdot)$:

$$X = G\left(x^1, \ldots, x^n\right) = \left[\sum_{i=1}^{n} (x^i)^{\rho_x} \right]^{1/\rho_x}$$

Similarly, the foreign aggregate good Y is made according to $H(\cdot)$:

$$Y = H\left(y^1, \ldots, y^m\right) = \left[\sum_{i=1}^{m} (y^i)^{\rho_y} \right]^{1/\rho_y}$$

---

tariff and subsidy is positive.

[7] Anderson, et. al. (1989) show that these CES demands arise naturally from the aggregation of consumers with Lancasterian preferences over characteristics. The key restriction needed is that the number of characteristics exceeds the number of varieties (models) minus one.

To summarize, consumers purchase cars (x^i's and y^i's), from which they make the aggregate goods X and Y. These X and Y are in turn used to make the services S from which consumers derive utility. Since consumers produce the services using a household production function, the price of a service equals its marginal cost. Firms' market power, of course, creates a wedge between the price and marginal cost of the products from which the services are produced.

Let $v^1, \ldots, v^n$ denote the prices of $x^1, \ldots, x^n$, and $w^1, \ldots, w^m$ denote the prices of $y^1, \ldots, y^m$. Let $p\left(v^1, \ldots, v^n\right)$ denote the marginal cost of producing X, and $q\left(w^1, ..., w^m\right)$ denote the marginal cost of producing Y using the household production functions $G(\cdot)$ and $H(\cdot)$, respectively. Let $g^i\left(v^1, \ldots, v^n\right) = \partial p\left(v^1, \ldots, v^n\right)/\partial v^i$ so that $g^i(\cdot)$ is the unit requirement of a particular x^i needed to make a unit of X. The demand faced by a single firm, x^i, is thus a derived demand given by:

$$x^i\left(v^1, \ldots, v^n, w^1, \ldots, w^m\right) = g^i\left(v^1, \ldots, v^n\right) \text{ (Demand for X)}$$

To obtain the demand for x^i, then, the demand for X must be found. This is also a derived demand, as it results from the demand from services. Let $C(p(\cdot), q(\cdot))$ equal the marginal cost of services S. Let $a(p(\cdot), q(\cdot)) = \partial C(\cdot)/\partial p(\cdot)$, the unit input requirement of X needed to make S. Let $D(C(\cdot))$ denote the demand for S.

Demand for x^i is thus.

$$x^i\left(v^1, \ldots, v^n, w^1, \ldots, w^m\right) = g^i\left(v^1, \ldots, v^n\right) a(\cdot) D(C(\cdot))$$

Similarly, let $h^i\left(w^1, \ldots, w^m\right) = \partial q\left(w^1, \ldots, w^m\right)/\partial w^i$ and $a^*\left(p(\cdot), q(\cdot)\right) = \partial C(\cdot)/\partial q(\cdot)$. Then the demand for y^i is given by:

$$y^i\left(v^1, \ldots, v^n, w^1, \ldots, w^m\right) = h^i(w^1, \ldots, w^m) a^*(\cdot) D(C(\cdot))$$

All that remains is to derive the actual forms of these functions from the CES parametrization. Equating the marginal utility of S with its marginal cost and inverting gives the demand for services:

$$D(C(\cdot)) = S = \left(\frac{C}{\alpha\beta}\right)^{\frac{1}{\alpha-1}}$$

The production functions for X and Y give rise to the associated cost functions:

$$p(v^1, \ldots, v^n) = \left[\sum_{i=1}^{n} \left(v^i\right)^{r_x}\right]^{1/r_x}$$

and

$$q(w^1, \ldots, w^m) = \left[\sum_{i=1}^{m} \left(w^i\right)^{r_y}\right]^{1/r_y}$$

where $r_x = \frac{\rho_x}{\rho_x - 1}$ and $r_y = \frac{\rho_y}{\rho_y - 1}$.

Differentiating $p(\cdot)$ and $q(\cdot)$ gives:

$$g^i(\cdot) = (v^i)^{r_x - 1}\left[\sum_{i=1}^{n}(v^i)^{r_x}\right]^{\frac{1}{r_x}-1}$$

and

$$h^i(\cdot) = (w^i)^{r_y - 1}\left[\sum_{i=1}^{m}(w^i)^{r_y}\right]^{\frac{1}{r_y}-1}$$

We assume that all firms within a country are identical. This symmetry assumption yields:

$$\begin{aligned} g(\cdot) &= n^{\frac{1-r_x}{r_x}} \\ h(\cdot) &= m^{\frac{1-r_y}{r_y}} \end{aligned}$$

and

$$\begin{aligned} p(\cdot) &= vn^{\frac{1}{r_x}} \\ q(\cdot) &= wm^{\frac{1}{r_y}} \end{aligned}$$

The production function for S gives rise to the associated cost function:

$$\begin{aligned} C(\cdot) &= \left(p^{\frac{\rho}{\rho-1}} + q^{\frac{\rho}{\rho-1}}\right)^{\frac{\rho-1}{\rho}} \\ &= (p^r + q^r)^{\frac{1}{r}} \end{aligned}$$

where $r = \frac{\rho}{\rho-1}$. Note that $p(\cdot)$ and $q(\cdot)$ are the (aggregate) prices which equal the cost of X and Y, and are thus not directly observable. The marginal cost of producing services is similarly unobservable.

Differentiating $C(\cdot)$ gives:

$$\begin{aligned} a(\cdot) &= (p^r + q^r)^{\frac{1}{r}-1} p^{r-1} \\ a^*(\cdot) &= (p^r + q^r)^{\frac{1}{r}-1} q^{r-1} \end{aligned}$$

which are the input requirements of X and Y per service S.

2.2 Calibration

We now calibrate the model. The first two equations used are those for demand. The relationships described above allow us to write the demands for $x^i(\cdot)$ and $y^i(\cdot)$ as:

$$x^i = \frac{n^{\frac{1-r_x}{r_x}}}{(\alpha\beta)^{\frac{1}{\alpha-1}}}\left(vn^{\frac{1}{r_x}}\right)^{r-1}\left(v^r n^{\frac{r}{r_x}} + w^r m^{\frac{r}{r_y}}\right)^{\frac{(\alpha-1)(1-r)+1}{(\alpha-1)r}}$$

and

$$y^i = \frac{m^{\frac{1-r_y}{r_y}}}{(\alpha\beta)^{\frac{1}{\alpha-1}}} \left(wm^{\frac{1}{r_y}}\right)^{r-1} \left(v^r n^{\frac{r}{r_x}} + w^r m^{\frac{r}{r_y}}\right)^{\frac{(\alpha-1)(1-r)+1}{(\alpha-1)r}}$$

Note that $x^i(v^1, \ldots, v^n, w^1, \ldots, w^m)$ and $y^i(v^1, \ldots, v^n, w^1, \ldots, w^m)$ thus depend on the variables n, m, v, w, r, r_x, r_y, α, and β, where n and m, the number of domestic and foreign firms, and v and w, domestic and foreign prices, are taken from the data.

Summing these demands over the n domestic firms and m foreign firms gives the demands for U.S. and Japanese autos. Since we assume that both markets clear, these demands are observable as actual sales, which we denote as Q_1 for U.S. cars, and Q_2 for Japanese cars:

$$Q_1 = \frac{n^{\frac{1}{r_x}}}{(\alpha\beta)^{\frac{1}{\alpha-1}}} \left(vn^{\frac{1}{r_x}}\right)^{r-1} \left(v^r n^{\frac{r}{r_x}} + w^r m^{\frac{r}{r_y}}\right)^{\frac{(\alpha-1)(1-r)+1}{(\alpha-1)r}} \tag{1}$$

and

$$Q_2 = \frac{m^{\frac{1}{r_y}}}{(\alpha\beta)^{\frac{1}{\alpha-1}}} \left(wm^{\frac{1}{r_y}}\right)^{r-1} \left(v^r n^{\frac{r}{r_x}} + w^r m^{\frac{r}{r_y}}\right)^{\frac{(\alpha-1)(1-r)+1}{(\alpha-1)r}} \tag{2}$$

Before we derive the remaining equations for the calibration, recall that the elasticity of substitution between domestic and foreign goods equals:

$$\sigma = \frac{1}{1-\rho} = 1 - r$$

which is defined so as to be positive. The analogous σ_x and σ_y parametrize the degree of substitutability between goods produced by two firms of the same nationality, with:

$$\sigma_x = 1 - r_x$$

and

$$\sigma_y = 1 - r_y$$

The demand elasticity for the aggregate good, ϵ, defined so as to be positive, equals:

$$\epsilon = -\frac{\partial D(C(\cdot))}{\partial C(\cdot)} \frac{C(\cdot)}{D(\cdot)} = \frac{1}{1-\alpha}$$

We next use a number of relationships implied by the CES structures. We use the demand functions for each good to derive firms' profit maximizing conditions. Before we do so, it is useful to define some elasticities, again so that the elasticities are typically positive. In general, μ denotes the price elasticity of demand of the various inputs:

$$
\begin{aligned}
\mu_i^i(x) &= -\frac{\partial g^i}{\partial v^i}\frac{v^i}{g^i}; \quad i = 1 \ldots n \\
\mu_j^i(x) &= \frac{\partial g^i}{\partial v^j}\frac{v^j}{g^i}; \quad i, j = 1 \ldots n \\
\mu_i^i(y) &= -\frac{\partial h^i}{\partial w^i}\frac{w^i}{h^i}; \quad i = 1 \ldots m \\
\mu_j^i(y) &= \frac{\partial h^i}{\partial w^j}\frac{w^j}{h^i}; \quad i, j = 1 \ldots m
\end{aligned}
$$

and

$$
\begin{aligned}
\mu &= -\frac{\partial a}{\partial p}\frac{p}{a} \\
\mu^* &= -\frac{\partial a^*}{\partial q}\frac{q}{a^*}
\end{aligned}
$$

Production shares for individual domestic and foreign firms equal:

$$\theta^i(x) = \frac{g^i v^i}{p}$$

and

$$\theta^{*i}(y) = \frac{h^i w^i}{q}$$

while aggregate domestic and foreign shares of expenditure equal:

$$\theta = \frac{ap}{C}$$

and

$$\theta^* = \frac{a^* q}{C}$$

Krishna and Itoh (1988) show that:

$$
\begin{aligned}
\mu &= \sigma/(1+\phi) \\
\mu^* &= \sigma\phi/(1+\phi) \\
\theta &= \phi/(1+\phi) \\
\theta^* &= 1/(1+\phi)
\end{aligned}
$$

where

$$\phi = (p/q)^r$$

Using these results and the assumption of symmetry between firms gives:

$$\begin{aligned}
\mu^{ii}(x) &= \frac{1}{n}(1-r_x)(n-1) \\
\mu^{ij}(x) &= \frac{1}{n}(1-r_x) \\
\theta^{i}(x) &= \frac{1}{n}
\end{aligned}$$

Differentiating $x^i(\cdot)$ gives domestic elasticities of demand:

$$\begin{aligned}
\epsilon^{ii}(x,x) &= -\frac{\partial x^i}{\partial v^i}\frac{v^i}{x^i} \\
&= \mu^i_i(x) + \theta^i(x)\mu + \epsilon\theta\theta^i(x) \\
&= \frac{1}{n}\left[(1-r_x)(n-1) + \frac{1-r+\epsilon\phi}{1+\phi}\right]
\end{aligned}$$

and

$$\begin{aligned}
\epsilon^{ij}(x,x) &= \frac{\partial x^i}{\partial v^j}\frac{v^j}{x^i} \\
&= \mu^i_j(x) - \theta^j(x)\mu - \epsilon\theta\theta^j(x) \\
&= \frac{1}{n}\left[(1-r_x) - \frac{1-r+\epsilon\phi}{1+\phi}\right]
\end{aligned}$$

Similarly, differentiating $y^i(\cdot)$ gives foreign elasticities of demand:

$$\begin{aligned}
\epsilon^{ii}(y,y) &= -\frac{\partial y^i}{\partial w^i}\frac{w^i}{y^i} \\
&= \mu^i_i(y) + \theta^i(y)\mu^* + \epsilon\theta^*\theta^i(y) \\
&= \frac{1}{m}\left[(1-r_y)(m-1) + \frac{(1-r)\phi+\epsilon}{1+\phi}\right]
\end{aligned}$$

and

$$\begin{aligned}
\epsilon^{ij}(y,y) &= \frac{\partial y^i}{\partial w^j}\frac{w^j}{y^i} \\
&= \mu^i_j(y) - \theta^j(y)\mu^* - \epsilon\theta^*\theta^j(y) \\
&= \frac{1}{m}\left[(1-r_y) - \frac{(1-r)\phi+\epsilon}{1+\phi}\right]
\end{aligned}$$

Note that $\epsilon^{ij}(a,b)$ is the elasticity of demand for the i^{th} good in country 'a' with respect to the price of the j^{th} good in country 'b'. For example, $\epsilon^{ii}(x,x)$ denotes domestic firms' own elasticity of demand, while $\epsilon^{ij}(y,y)$ represents foreign firms' cross-elasticity of demand when both i and j are foreign goods. Similarly, cross-elasticities of demand between the goods of different countries equal:

$$\begin{aligned}\epsilon^{ij}(x,y) &= \frac{\partial x^i}{\partial w^j}\frac{w^j}{\partial x^i} \\ &= \frac{1}{m}\left[\frac{1-r-\epsilon}{1+\phi}\right]\end{aligned}$$

and

$$\begin{aligned}\epsilon^{ij}(y,x) &= \frac{\partial y^i}{\partial v^j}\frac{v^j}{\partial y^i} \\ &= \frac{1}{n}\left[\frac{(1-r-\epsilon)\phi}{1+\phi}\right]\end{aligned}$$

We are now ready to use firms' first order conditions for profit maximization. The profits of a typical U.S. firm are:

$$\pi^i = (v^i - d + s)x^i(v^1, \ldots, v^n, w^1, \ldots, w^m)$$

where s is the specific subsidy to home firms, and d is the (constant) domestic marginal cost of production. This yields the first order condition for U.S. firms:

$$\epsilon^{ii}(x,x) - \gamma = v^i/(v^i - d + s) \tag{3}$$

with conjectural variations:

$$\gamma = (n-1)\epsilon^{ij}(x,x)\gamma^{11} + m\epsilon^{ij}(x,y)\frac{v}{w}\gamma^{12}$$

where

$$\begin{aligned}\gamma^{11} &= \frac{\partial v^j}{\partial v^i} \\ \gamma^{12} &= \frac{\partial w^j}{\partial v^i}\end{aligned}$$

Similarly, the first order condition for Japanese firms is:

$$\epsilon^{ii}(y,y) - \gamma^* = w^i/(w^i - d^* - t) \tag{4}$$

where t is the specific tariff on the foreign firm, and d^* is the foreign (constant) marginal cost of production. The foreign conjectural variations are thus:

$$\gamma^* = n\epsilon^{ij}(y,x)\frac{w}{v}\gamma^{21} + (m-1)\epsilon^{ij}(y,y)\gamma^{22}$$

where

$$\begin{aligned}\gamma^{21} &= \frac{\partial v^j}{\partial w^i} \\ \gamma^{22} &= \frac{\partial w^j}{\partial w^i}\end{aligned}$$

We now have 4 equations, but 7 unknowns: γ, γ^*, α, β, r, r_x, and r_y. There are many possible ways to complete the calibration; available elasticity estimates typically determine the route chosen. Since Dixit cites several estimates for ϵ, the total elasticity of demand for all automobiles, and σ, the elasticity of substitution between U.S. and Japanese cars, we employ these in the calibration. Following Dixit, we take 2.0 as the base case for σ and perform sensitivity analysis using values of 1.5 and 3.0. For ϵ, Dixit's figure of 1.0 would imply $\alpha = 0$. We therefore use 1.1 as our central case, and perform sensitivity analysis for values of 1.05, 1.30, and 1.50.[8] Table 10 contains the results of this sensitivity analysis, which we describe in Section 3.4. For U.S. and Japanese cars to be substitutes, e.g. $\epsilon^{ij}(x, y) > 0$, ϵ must be less than σ, so that we report no results for the case where both ϵ and σ equal 1.50.

Given data for v, w, n, m, Q_1, and Q_2, and estimates for ϵ and σ, the demand equations (1) and (2) become a system of 2 equations with the 3 unknowns β, σ_x, and σ_y. We solve the system recursively. Dividing (1) by (2) eliminates β. Taking as given a value for σ_y then gives σ_x. Substituting σ_x into (1) or σ_y into (2) gives β.

Since Japanese cars are probably closer substitutes for one another than they are for U.S. cars, σ_y should be larger than σ. We take σ_y as 3.0 for our central case; this is larger than the central case estimate for σ of 2.0.[9] As described in Section 3.4, Table 11 shows the effects of changing σ_y on firms' implied conduct. In general, a larger σ_y implies that Japanese firms act more collusively, since they persist in charging a price above marginal cost even as their products become less distinguishable. The effect on the implied conduct of U.S. firms is small.

Given σ_x and σ_y, we can calculate ϕ as $(p/q)^r$. Another way to get ϕ would be to use the identity $\theta = \phi/(1+\phi)$. This utilizes the fact that θ, which equals ap/C, is simply domestic producers' share in expenditure. Thus, using the data described below to find θ determines the value of ϕ. The calibration procedure ensures that both methods produce the same ϕ.

Once we know ϕ, r, ϵ, r_x, and r_y, the first order conditions (3) and (4) provide γ and γ^*. These can in turn be decomposed into the component γ^{ij}'s using the definitions of γ and γ^* given above. Since there are four γ^{ij}'s and only two equations that define them, we must set either $\gamma^{11} = \gamma^{12}$ and $\gamma^{21} = \gamma^{22}$, or set $\gamma^{11} = \gamma^{22}$ and $\gamma^{12} = \gamma^{21}$. We discuss the implications of these alternative assumptions in Section 3.1.

[8] Further evidence is provided by de Melo and Tarr (1989), who take the price elasticity of demand as 1.1 for U.S. cars, and 1.2 for foreign cars.

[9] While this value for σ_y might seem arbitrary, the choice of σ_y does not at all affect the resulting prices, welfare, or optimal policies.

2.3 Data

Our data, which is contained in Table 1, comes from predominantly the same sources as that of Dixit. Prices and quantities for both U.S. and Japanese cars are taken from the *Automotive News Market Data Book* (ANMDB), which is also the source (indirectly) of Dixit's data for 1979, 1980, and 1983. Prices are the suggested retail price for March or April of each year, exclusive of optional equipment and domestic transport costs. Japanese prices include import duties and freight charges. Quantities are the total of all models sold. Though for U.S. cars this differs from Dixit's use of production minus exports plus imports from Canada, the difference is for all years far less than 1%.

As always, cost data is more difficult to obtain. We use Dixit's cost figures for 1979, 1980, and 1983, and adjust these figures for other years, following the method described by Dixit. For domestic autos, production costs are broken into labor and component/materials costs. Labor costs are adjusted in each year by Bureau of Labor Statistics (BLS) figures for automobile industry compensation rate changes, and then by an additional 2% for productivity changes. Component/materials costs are adjusted by the wholesale price index from the IMF *International Financial Statistics* (IFS). For Japanese costs, we use the IFS Manufacturing Wages index to adjust Dixit's figures for materials costs, the IFS Wage/Price index for labor costs, IFS statistics for exchange rate changes, and data from the World Bank *Commodity Trade and Price Trends* to adjust for changes in ocean freight costs.

We use market share data in the ANMDB to calculate Herfindahl numbers-equivalents on a firm basis, which we denote as n for the U.S., and m for Japan.[10]

3 Implementing the Model

We use the data in Table 1 to calibrate the model for the year 1979 to 1985. The resulting parameter values for market (consumer) and firm behavior are summarized in Tables 4 and 6, respectively.

3.1 Calibration Results

Table 4 summarizes the parameters which describe market (consumer) behavior. For $\sigma_y = 3.0$, the value of σ_x is remarkably constant and lies around 1.3 for all years. That the elasticity of substitution between U.S. goods always lies below

[10] Note that since we assume product differentiation within each country, the Herfindahl numbers-equivalent—the number of symmetric firms which would reproduce the existing market shares—is not really the proper measure, as the number of firms n and m are not truly exogenous. Our use of the Herfindahl index should thus be taken as an approximation. It is a simple matter to add two equations to endogenize n and m. While the results change very little, the computational burden becomes much greater.

that for Japanese goods suggests that U.S. autos are less close substitutes for one another than Japanese autos. This seems plausible as U.S. cars seem more differentiated than Japanese cars.

This is reflected in the elasticities of demand. That $\epsilon^{ii}(x,x)$ and $\epsilon^{ij}(x,x)$ are respectively smaller than $\epsilon^{ii}(y,y)$ and $\epsilon^{ij}(y,y)$ shows that the price elasticity of demand for Japanese cars with respect to other Japanese cars is more elastic than that of U.S. cars with respect to other U.S. cars. Indeed, the demand for Japanese cars in general reacts more to price changes, both by national and international competitors. This is shown by $\epsilon^{ij}(y,x)$ being an order of magnitude larger than $\epsilon^{ij}(x,y)$. The two 'own' elasticities $\epsilon^{ii}(x,x)$ and $\epsilon^{ii}(y,y)$ are orders of magnitude larger than the ϵ^{ij}'s because they reflect the effect on a firm which raises its own price, and thus loses demand to all other firms. The four ϵ^{ij}'s, on the other hand, are smaller because they measure the gain of only one of the many firms which benefit when another firm changes its price.

As a further check on these demand elasticities, we calculate the resulting aggregate cross-elasticities of demand, and compare them to estimates in Levinsohn (1988).[11] The U.S.-U.S. cross-elasticity, which we denote as $L(Q_1,v)$, is the percent quantity change in U.S. autos given an equi- proportionate change in the price of all U.S. cars. Similarly, we denote the U.S.-Japan cross-elasticity—the response of U.S. sales to an equi-proportionate change in Japanese prices—as $L(Q_1,w)$. The Japan-Japan and Japan-U.S. cross-elasticities are $L(Q_2,w)$ and $L(Q_2,v)$, respectively. As usual, we define these elasticities so that they are typically positive.

For our specification:

$$\begin{aligned} L(Q_1,v) &= -\frac{\partial nx\left(v^1,\ldots,v^n,w^1,\ldots,w^m\right)}{\partial v}\frac{v}{nx} \\ &= \epsilon^{ii}(x,x)-(n-1)\epsilon^{ij}(x,x) \\ &= \frac{1-r+\epsilon\phi}{1+\phi} \end{aligned}$$

$$\begin{aligned} L(Q_1,w) &= \frac{\partial nx(v^1,\ldots,v^n,w^1,\ldots,w^m)}{\partial w}\frac{w}{nx} \\ &= m\epsilon^{ij}(x,y) \\ &= \frac{1-r-\epsilon}{1+\phi} \end{aligned}$$

$$L(Q_2,w) = -\frac{\partial my(v^1,\ldots,v^n,w^1,\ldots,w^m)}{\partial w}\frac{w}{my}$$

[11] Levinsohn's estimates come from an econometric study using a panel of data for 100 different models over the years 1983 to 1985. He presents four different estimates for each of the cross-elasticities, which he takes as constant over the years examined. See Levinsohn (1988), Tables 2.4 to 2.7.

$$= \epsilon^{ii}(y,y) - (m-1)\epsilon^{ij}(y,y)$$
$$= \frac{(1-r)\phi + \epsilon}{1+\phi}$$

$$L(Q_2, v) = \frac{\partial my(v^1,\ldots,v^n,w^1,\ldots,w^m)}{\partial v}\frac{v}{my}$$
$$= n\epsilon^{ij}(y,x)$$
$$= \frac{(1-r-\epsilon)\phi}{1+\phi}$$

Table 4 contains the aggregate cross-elasticities which result from our model, along with the ϵ^{ij}'s— the individual firm elasticities of demand. Our results of 1.200 to 1.264 for $L(Q_1, v)$ correspond well with Levinsohn's estimates of 0.967 to 1.412. For $L(Q_1, w)$, our results of 0.100 to 0.164 are similarly roughly in line with Levinsohn's estimates of 0.086 to 0.226. Note that after 1979, U.S. firms become markedly more responsive to changes in Japanese prices; this corresponds to the year in which U.S. auto manufacturers first appealed for import protection. However, our results of 1.836 to 1.900 for $L(Q_2, w)$ differ significantly from Levinsohn's estimates of 1.080 to 1.636, while our results of 0.730 to 0.800 for $L(Q_2, v)$ differ from Levinsohn's figures of 0.122 to 0.231.

An alternate approach to the calibration sheds light on the implications of these differences. Since ϕ can be calculated from market share data, taking values for the own- country cross-elasticities $L(Q_1, v)$ and $L(Q_2, w)$ lets us solve for ϵ and σ. The rest of the calibration then proceeds as before. Table 5 shows the behavioral parameters and jointly optimal policies and welfare which result from taking $L(Q_1, v)$ as 1.247, and $L(Q_2, w)$ as 1.636, which are the Levinsohn estimates with the smallest standard errors. Except in 1982 and 1983, $\epsilon^{ij}(x,x)$ is negative, indicating that U.S. cars are complements for one another, rather than substitutes. While the optimal policies and welfare do not change by much, this improbable result makes us wary of Levinsohn's estimate for $L(Q_2, w)$.

Table 4 also summarizes the values of β, which gives an indication as to the strength of demand. While demand for autos was relatively strong in 1979, it weakened in 1980, a year in which the three major U.S. producers all suffered losses.[12] This is picked up by the fall in β between these years. The rise in β in 1983 coincides with U.S. firms' comeback, as Ford and General Motors edged back into profitability after the dismal years (for U.S. firms) of 1980 through 1982.

Table 6 summarizes the parameters which describe firm behavior. The estimates of γ and γ^*, parametrize the degree of competition among U.S. and Japanese firms, respectively. A value of γ of zero indicates Bertrand competition. The estimates derived are uniformly negative, suggesting that firms'

[12] Halberstam (1986) provides a fascinating history of the U.S. and Japanese automobile industries.

behavior is more competitive than that of Bertrand oligopolists. This contrasts with Dixit's result that competition lies somewhere between Cournot and Bertrand. With Dixit's assumption of perfect substitutability between all home goods and between all foreign goods, any markup of price over cost implies conduct less competitive than Bertrand. By introducing product differentiation within goods made at home and within those made abroad we do not implicitly restrict the calibrated conjectures in this way.

From 1979 to 1980, these conjectures become more negative, suggesting a greater degree of competition in 1980 than in 1979. This is not surprising, as demand was relatively slack in 1980. With the VER's in place starting in 1981, Japanese firms appear to behave less competitively, while the U.S. firms continue to act in a relatively competitive manner. This is consistent with Dixit's results that collusion between U.S. firms does not appear to be greatly strengthened by the VER's. By 1984, however, U.S. firms appear to match Japanese firms in acting less competitively, though both continue to behave more competitively than Bertrand duopolists. The VER's, then, seem to have prodded U.S. firms to competitive behavior in order to catch up to Japanese firms, after which they reverted to relatively collusive behavior.

We also decompose the γ and γ^*'s into their component γ^{ij}'s . We either assume that $\gamma^{11} = \gamma^{12}$ and $\gamma^{21} = \gamma^{22}$ or that $\gamma^{11} = \gamma^{22}$ and $\gamma^{12} = \gamma^{21}$. Table 6 summarizes the calibrated values of both sets of these γ^{ij}'s.

Assuming that $\gamma^{11} = \gamma^{12}$ and $\gamma^{22} = \gamma^{21}$ implies that firms have the same conjectures about home and foreign firms. This does not seem like a good idea for the years with a VER. For this specification, both sets of γ^{ij}'s are negative. That $\gamma^{11} = \gamma^{12}$, the conjectures of U.S. firms, is consistently more negative than the $\gamma^{21} = \gamma^{22}$ conjectures of Japanese firms reflects the interpretation of the aggregate γ and γ^*, that U.S. firms behave more competitively than Japanese firms.

Assuming that $\gamma^{11} = \gamma^{22}$ and $\gamma^{12} = \gamma^{21}$ implies that domestic firms' conjectures about other domestic firms is the same as the foreign firms' conjectures about other foreign firms, and similarly that each nation's firms hold identical conjectures about firms in the other nation. U.S. and Japanese firms are thus required to behave similarly, which may again not be true. In this case, firms' conjectures about competitors in the same country, $\gamma^{11} = \gamma^{22}$, are positive, while $\gamma^{12} = \gamma^{21}$, firms' conjectures about competitors in the other country, are negative. This implies that firms within a country collude, while competing with firms of the other country. This finding coincides with a widespread U.S. view of Japanese firms' behavior. Note that in 1984 and 1985, the degree of collusion within each country falls markedly, even though the aggregate conjectures γ and γ^* become less negative—that is, more collusive. This occurs because $\gamma^{12} = \gamma^{21}$ also rises sharply (becomes less negative), with the decreased response to overseas competitors outweighing the lessened collusion with regard to domestic competitors.

In order to better interpret the meaning of the values of γ and γ^* we also calculate the prices of U.S. and Japanese autos which would exist were behavior Bertrand or Cournot. The Bertrand-equivalent prices are calculated by solving for v and w in (3) and (4), assuming that γ and γ^* are zero and substituting for $\epsilon^{ii}(x,x)$ and $\epsilon^{ii}(y,y)$, while taking the actual number of firms n and m as given. These are given by v_B and w_B in Table 6.

To calculate the Cournot-equivalent prices, we solve (3) and (4) in conjunction with equations (5) - (8) given below, which restrict firms' beliefs (γ^{ij}'s) to competition in quantities. The Cournot-equivalent prices v_C and w_C, along with the γ^{ij}'s and aggregate γ_C and γ_C^*, are presented at the bottom of Table 6.[13]

For a U.S. firm to assume that other U.S. firms do not vary their output it must assume that prices change so that:

$$\epsilon^{ij}(x,x)\left(1+(n-2)\gamma^{11}\right)-\epsilon^{ii}(x,x)\gamma^{11}+m\epsilon^{ij}(x,y)\gamma^{12}\frac{v}{w}=0 \qquad (5)$$

For a U.S. firm to assume that Japanese firms do not change their output, it must assume that:

$$\epsilon^{ij}(y,x)\left(1+(n-1)\gamma^{11}\right)+\frac{v}{w}\gamma^{12}\left[\epsilon^{ij}(y,y)(m-1)-\epsilon^{ii}(y,y)\right]=0 \qquad (6)$$

Similarly, for a Japanese firm to assume that other Japanese firms do not change their output as it varies its own price it must assume that:

$$\epsilon^{ij}(y,y)\left(1+(m-2)\gamma^{22}\right)-\epsilon^{ii}(y,y)\gamma^{22}+n\epsilon^{ij}(y,x)\gamma^{21}\frac{w}{v}=0 \qquad (7)$$

For a Japanese firm to assume that U.S. firms do not vary their output it must assume that:

$$\epsilon^{ij}(x,y)\left(1+(m-1)\gamma^{22}\right)+\frac{w}{v}\gamma^{21}\left[\epsilon^{ij}(x,x)(n-1)-\epsilon^{ii}(x,x)\right]=0 \qquad (8)$$

For firms to behave in a Cournot fashion and for this behavior to replicate the market outcome, v, w, γ^{11}, γ^{12}, γ^{21}, γ^{22} must be such that equations (3) - (8) are satisfied simultaneously.

Because we find behavior to be less collusive than that of Bertrand oligopolists, the Bertrand-equivalent price for both domestic and foreign cars is higher than the actual price, while the Cournot-equivalent price is higher still. Note, however, that while the Bertrand and Cournot-equivalent prices for U.S. firms are

[13] Unlike Dixit (1988), the analogous Bertrand and Cournot-equivalent number of firms cannot be computed. This results from the highly non-linear appearance of n and m in ϕ, which leads to a multiplicity of solutions. In contrast, because v and w appear in a linear fashion in ϕ, there are only 2 solutions for each of v_B, w_B, v_C, and w_C. One solution gives the economically nonsensical result of price less than net cost—that is, $v < d+s$ or $w < d^* - t$; we present the other.

much higher than actual prices, the equivalent prices for Japanese firms are quite close to actual prices v and w, which are shown in the middle of Table 6. This indicates that Japanese firms' behavior is fairly close to that of Bertrand (and Cournot) oligopolists, while U.S. firms exhibit far more competitive behavior.

The γ^{ij}'s which result from finding the Cournot- equivalent prices give an indication of how firms' prices would react to each other, were the firms competing in quantities. Of the four, γ^{21}, the change in U.S. firms' price in response to a change in the Japanese price, is by far the largest, with γ^{22}, the own-country Japanese response, next largest. Japanese firms thus seem to 'drive' the market, in that both U.S. and other Japanese firms react most strongly to changes in the Japanese price. That γ^{11}, the change in U.S. price, is negative implies competitive behavior between hypothetical quantity-competing U.S. firms. These results suggest that even if in the aggregate, conjectures were Cournot for all firms, asymmetries in conjectures remain.

3.2 Welfare

We now calculate the optimal policies which arise from maximization of the welfare function. The first order conditions (3) and (4) together define how domestic price, v, and foreign price, w, adjust for a given subsidy, s, and tariff, t. In turn, v and w determine U.S. and Japanese outputs. Since v and w are non-linear simultaneous functions of s and t, (3) and (4) must be solved numerically for every s and t. The resulting v and w are then used to calculate a value for welfare. The jointly optimal subsidy and tariff are thus the s and t which maximize the welfare function. For the optimal tariff by itself, s is set to 0, while for the optimal subsidy by itself, we set t to the MFN level of \$100.[14]

As explained in section 2.1, we assume a numeraire good, n_0, and a utility-maximizing aggregate consumer. We assume that all revenues are given back to this aggregate consumer, so that welfare is given by:

$$W(s,t) = U(S(s,t)) - ndx(s,t) - (w-t)my(s,t)$$

when there are no rents to labor. Following Dixit, we assume labor rents to be a constant 20% of the domestic cost in each year. For 1979, Dixit notes that this corresponds to about half of the wage bill. Rents are then subtracted out from domestic cost d in the second term of the welfare function.[15]

[14] In our base calculations we do not disaggregate γ and γ^* into their γ^{ij} components, since neither disaggregation is particularly appealing given the restrictions required to get a solution. Moreover, disaggregation greatly increases the non-linearity of the system, making it much more difficult to find a real solution. Two further equations are needed to fully describe firm interactions.

[15] With Labor Rent L: $W(s,t) = U(S(s,t)) - n(d-L)x(s,t) - (w-t)my(s,t)$.

3.3 Optimal Policies

Tables 2 and 3 summarize the policy and welfare results for the years 1979 to 1985. In all tables, welfare is shown in billions of dollars. The first thing to notice is that in all years the jointly optimal policy is to subsidize both domestic production and imports. This contrasts with Dixit's results, which call for a subsidy on domestic production, but a tariff on imports.

In order to understand why the sign of the import policy differs between our model and Dixit's, consider the derivative of welfare with no labor rents at t and s equal to zero:

$$\frac{\partial W}{\partial t}\Big|_{s=t=0} = n(U_x - d)\frac{\partial x}{\partial t} - my(\frac{\partial w}{\partial t} - 1)$$

Note that at this point there are only two terms in this expression. The first term is positive in both models, since marginal utility equals price which exceeds costs, and since a tariff raises domestic production in both models, which implies that $\partial x/\partial t$ is positive. In Dixit's model, however, $\partial w/\partial t$ is less than unity while it exceeds unity in ours. Hence the second term, $-my(\partial w/\partial t - 1)$, is positive in Dixit's model but negative in ours. As the welfare function is well behaved this leads to the optimal tariff being positive in his model. In ours, the second term outweighs the first at $s = t = 0$, so that a subsidy on imports improves welfare.

Intuitively, trade policy seems to play two roles here. The first is a profit shifting role in correcting any 'strategic distortion' a lá Eaton and Grossman (1986). Second, since trade policy affects domestic consumption, it also affects the size of consumer surplus. Our model implies that behavior is fairly competitive. This by itself should work towards reversing the sign of the optimal trade policy, since the direction of the profit shifting policy depends on the degree of competition. In addition, our CES demand parametrization implies that consumer surplus is quite important, since demand resembles a hyperbola. This in turn strengthens the reasons to subsidize both domestic and foreign output. Hence we believe that the calibration results for implied conduct together with the effect of the demand parametrization itself on the importance of consumer surplus in welfare is responsible for our results differing from Dixit's.

Next compare the jointly optimal subsidy when there are no labor rents to the case with labor rents. With rents, the optimal policy involves a higher subsidy on production than without. This is to be expected as the presence of rents makes domestic production more desirable. Also notice that the optimal tariff changes only very slightly. This suggests a targeting interpretation. The presence of labor rents distorts production, as firms produce too little, both because they have monopoly power and because they do not take labor rents into account in their production decisions. Hence the optimal policy to correct this distortion is a domestic production subsidy, which targets the domestic distortion directly, rather then a trade policy, which targets the distortion only indirectly.

When the production subsidy is unavailable, the optimal tariff in the presence of labor rents is positive for all years, as opposed to the import subsidy typically optimal in the absence of labor rents. Again this is expected as the tariff must partly do the job of the unavailable production subsidy, and the higher tariff encourages domestic production. The presence of labor rents thus dramatically changes the nature of the optimal policies.

Next compare the jointly optimal tariffs with and without labor rents to the optimal tariffs when a production subsidy is unavailable. The tariff is always larger (less negative) in the latter case. Again, this has a targeting interpretation. When a subsidy is unavailable, the tariff targets the monopoly distortion which is really best targeted by the subsidy. Similarly, comparing the jointly optimal subsidy and the optimal subsidy when the tariff is set to the MFN level shows that the subsidy is slightly lower when applied by itself. When the tariff is not available, reducing the subsidy on production acts to encourage imports.

In the above comparisons we see at work the general principle of targeting instruments to the relevant distortion. We also see that in the absence of an instrument, the optimal levels of the remaining instrument is set to help reduce other distortions. Dixit offers similar interpretations.

A natural question to ask next is how valuable such policy is in raising welfare. The welfare levels with both t and s set optimally, with only t set optimally, and with only s set optimally are given in Tables 2 and 3. Here our results are in line with Dixit's—the gains to be had are very limited, with most of the benefit coming from the production subsidy rather than a tariff on imports.

In the absence of labor rents, gains range from a high of about \$5 billion in 1985 to less than \$80 million in 1980.[16]

Welfare gains are larger when labor rents constitute a share of the domestic wage bill, since the increased domestic production which results from optimal policies adds to consumer surplus and to workers' rents, both of which the price-setting firm ignores. With our assumption of labor costs as 20% of unit cost (half of the wage bill), welfare gains from jointly optimal policies range from \$13 billion in 1985 to \$1.7 billion in 1985. The presence of labor rents thus provides greater scope for strategic trade policy.[17] And yet these gains remain fairly minor relative to the size of the markets involved.

Moreover, it may be worse to implement the wrong policy than to do nothing. For example if the optimal policies which result from use of Dixit's model are used instead of the optimal ones as calculated by our model, welfare is slightly lower in some years. Table 7 compares the status quo (MFN tariff, no subsidy) welfare level (W^{MFN}) with the welfare which results from application of the optimal policies suggested by our CES model (W^{CES}), and the welfare

[16]Potential gains in 1985 are particularly large because firm behavior in that year is not very competitive. This increases the welfare gains available from increasing output with a production subsidy.

[17]See, for example, Katz and Summers (1988).

which results from Dixit's optimal policies (W^D). Implementing Dixit's policies reduces welfare in the absence of labor rents in 1981, 1982, 1983, and 1985 but raises welfare over inaction in the remaining years. With labor rents Dixit's policies reduce welfare in 1985 but increase it in other years. Of course, the lack of responsiveness in welfare also implies that the loss from following the wrong policies is likely to be small—a conclusion borne out for 1981 to 1983. In 1985, however, application of the optimal tariff and subsidy which result from Dixit's model entails a decline in welfare of more than $4 billion without labor rents, and of $50 billion in the presence of labor rents. Misguided policy decisions can indeed prove costly in certain cases.

As shown by Krishna (1985), however, quantitative restraints such as VER's differ fundamentally from tariffs in that they facilitate collusive behavior by the competing firms. The existence of VER's starting in 1981 thus affects firm behavior, as reflected in the conjectural variations parameters γ and γ^*. The rise in γ^* corresponding to the imposition of VER's in 1981, and in γ after 1983, supports this theory. Our simulation results for these years, however, take γ and γ^* as fixed behavioral parameters. These CV's are surely inappropriate for calculating the optimal tariff and subsidies, since these policies do not have the collusion- increasing effects of VER's.

As an attempt to correct for this problem of static CV's, we double the γ and γ^* which result from the calibration for 1983 before finding the optimal subsidy and tariff. This experiment, which makes γ and γ^* more negative, thus imposes the more competitive conjectures Krishna (1985) tells us should exist in the absence of a VER. Of course, we have no way of knowing whether our adjustment is sufficient (or too much); we mean this only as a first step.

Table 8 compares the prices, policies, and welfare which result from the modified CV's for 1983 with those from the original CV's, both at the actual MFN tariff, and at the jointly optimal policy. The first two columns compare the actual MFN tariff with the results of the modified CV's. Without the VER, both domestic and foreign prices would be lower, and consumption of both countries' cars higher. Welfare rises by about $700 million or $1.1 billion, depending on whether labor rents exist. This experiment thus highlights the point that a tariff is a far better (efficiency-wise) instrument with which to protect domestic industries than a quantitative restraint. The third column shows the quota-equivalent tariff rate; that is, the tariff (to the nearest dollar) required to duplicate the original level of Japanese imports assuming the less collusive conjectures. Notice that for the same volume of imports, U.S. production is substantially larger than under the VER.

The next two columns compare the jointly optimal subsidy and tariffs outcomes with the results of modifying the CV's. The more competitive behavior on the part of firms lessens the size of the oligopoly distortions, so that both domestic and import subsidies decline. U.S. producers thus lose some market share to Japanese firms, but the increased consumer surplus results in a slight gain in welfare.

3.4 Sensitivity Analysis

We next consider how sensitive our results are to the calibration parameters we obtain from outside sources. In the interest of brevity, we present sensitivity results only for 1979; similar results obtain for the other years.

Table 9 shows the effect of changing U.S. and Japanese costs over the same range considered by Dixit. This affects firms' behavioral parameters γ and γ^*, and the resulting optimal policies and welfare. Notice that the estimate of γ (γ^*) becomes more negative as costs in the U.S. (Japan) rise, since a smaller markup of price over marginal cost indicates more competitive behavior. Similarly, γ and γ^* rise to reflect more collusive behavior as costs decline, though both remain negative for the range of plausible costs.

As Japanese costs rise, the optimal subsidy falls slightly, while the optimal tariff rises markedly, though it remains negative. Similarly, as U.S. costs rise, the optimal subsidy falls, while the optimal tariff remains relatively constant. This further reinforces the targeting interpretation given before. As Japanese firms' costs rise, their implied behavior becomes more competitive, thereby reducing the desirability of subsidizing imports. Similarly, as U.S. costs rise, implied U.S. firm behavior becomes more competitive, reducing the size of the domestic distortion targeted by the subsidy.

Welfare at the optimum falls when U.S. costs rise, since the resource costs of production enter the welfare function directly. Welfare is relatively unaffected by Japanese costs, since these enter only via their impact on prices. Again, however, welfare falls as higher costs mean higher prices.

Table 10 shows the sensitivity of our results to the assumed values for ϵ and σ. While the choice of ϵ significantly alters the resulting optimal welfare level, the behavioral parameters and the optimal subsidy and tariff levels change only slightly for reasonable values of σ and ϵ. Furthermore, as ϵ rises, $\epsilon^{ij}(x,x)$ and $\epsilon^{ij}(y,y)$ become negative, which implies that autos are complements in demand. Our parametrization thus puts an upper bound of about 1.3 on the total elasticity of demand. As σ rises, U.S. and Japanese cars become more similar to consumers, so that firms' implied behavior becomes more collusive. The optimal subsidy rises, along with the tariff, which becomes less negative.

Table 11 shows the sensitivity analysis for σ_y. As σ_y increases, σ_x rises only slightly, and σ_y always remains larger. American cars are thus quite differentiated from one another, as opposed to Japanese cars, which are far more substitutable in demand. As σ_y becomes large, Japanese cars become closer substitutes, and γ^* becomes very large, implying substantial collusion between Japanese firms. Without differentiation between Japanese cars, any markup of price above cost is evidence of monopoly power. A small σ_y, on the other hand, results in implausible negative values for $\epsilon^{ij}(x,x)$ and $\epsilon^{ij}(y,y)$. We thus find a lower bound on σ_y of about 2.0. Again, however, the choice of σ_y does not at all affect the prices which satisfy (3) and (4) or the resulting optimal policies and welfare. An econometrically derived estimate for σ_y would thus allow a more definitive determination of Japanese firms' behavior, but would not otherwise affect our results.

These sensitivity analyses imply that the calibration results and the optimal policies are quite insensitive to changes in the parameter values, with the exception of costs. This highlights our point that what is most important is not the parameter values, but rather the specification of the model itself.

4 Conclusion

Our results indicate that simple calibration models of trade in oligopolistic industries are quite sensitive to the model structure imposed. Though we have taken one step in elaborating Dixit's model, further extensions seem worthwhile.

As noted previously, further disaggregation such as between large cars and small cars would more accurately reflect industry conditions. Whether this would give strikingly different results, however, is uncertain. What is clear, however, is that the resulting model would be extremely complex; our model is already highly non-linear. Further differentiation would require a substantial amount of additional data, perhaps broken down as far as by each particular model. Much of this, such as market share data, is publicly available; obtaining other data, particularly costs and elasticities of substitution would no doubt prove more elusive. Feenstra and Levinsohn (1989) provide an excellent beginning.

Less difficult to implement would be the inclusion of quality effects, an extension on which we are currently at work. Indeed, many studies examine the effects of trade policy on quality upgrading; Feenstra (1988) focuses on the Japanese auto industry. In unpublished work, we show that Dixit's calibration procedure cancels out quality effects, so that quality upgrading plays no role in the determination of optimal policies in his model.[18] This clearly unsatisfactory result stems primarily from Dixit's linear demand structure, and is hopefully not a general feature of calibration models.

One result common to both our model and Dixit's is that the presence of labor rents substantially enlarges the potential benefits of optimal trade policies. This is particularly important since wages in import-competing industries such as steel and autos probably include a large rent component. Following Dixit, we include only the most rudimentary attempt at capturing the effects of these rents. Endogenizing the wage process through inclusion of a formal model of union-firm bargaining (cooperative or not), would no doubt provide great insight. Eaton (1988) provides several suggestions for fruitful research, and work on this is under way.

Our results similarly accord with Dixit's in that we find a surprising amount of 'targeting' of instruments to particular distortions. Only limited theoretical work exists on targeting rules for oligopolistic industries analogous to targeting

[18] The proof, which will appear in future work, is available from the authors.

rules for distortions in competitive industries. Krishna and Thursby (1988) provide a beginning, but there remains more work to be done.

Lastly, we make only a limited attempt to take into account the effects of preexisting quantitative restraints on firms' behavioral conjectures. A more satisfactory way to measure firm interactions is clearly necessary. Recent work on Markov Dependent Stochastic Games, such as Driskill and McCafferty (1988), may prove useful here.

For the present, however, our results suggest that the policy recommendations of simple calibrated trade exercises should be interpreted with extreme caution. Moreover, as the gains from activist policy appear quite small, the case for activist policy is far from clear. However, such exercises provide valuable insights into the behavior of firms over time, and the effects of policies on this behavior. They also provide good estimates of demand elasticities. But our understanding of calibrated trade models is far from perfect, and more work is clearly necessary. Until our ability to apply theory to actual industry conditions improves, it remains vital not to oversell such models to policy makers.

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Table 1: Data

		1979	1980	1981	1982	1983	1984	1985
Autos	Q_1	8.341	6.581	6.206	5.756	7.020	7.952	8.205
(million)	Q_2	1.546	1.819	1.833	1.831	2.112	2.300	2.300
Price	v	5951	6407	6740	6880	7494	8950	10484
($)	w	4000	4130	4580	4834	5239	5518	6069
Cost	d	5400	6100	6362	6636	7000	7301	7615
($)	d^*	3400	3800	3963	4121	4400	4589	4786
Firms	n	2.250	2.077	2.100	2.200	2.262	2.300	2.310
	m	4.040	4.034	4.210	4.250	4.350	4.460	4.400
Labor Rent		1000	1200	1272	1327	1400	1460	1523
Total Elasticity of Demand					$\epsilon = 1.1$			
Elasticities of Substitution					$\sigma = 2.0$			
					$\sigma_y = 3.0$			

Table 2: Policy Results — No Labor Rent

	1979	1980	1981	1982	1983	1984	1985
Jointly Optimal Policies							
subsidy	528	312	404	299	528	1397	2141
tariff	-245	-122	-267	-318	-377	-410	-559
v	5369	6079	6312	6570	6929	7239	7543
w	3606	3895	4166	4355	4684	4918	5249
Q_1	9,339,751	6,966,457	6,641,044	5,996,488	7,611,905	10,170,626	12.041,257
Q_2	1,734,165	1,949,192	2,078,808	2,142,709	2,449,221	2,423,089	2,335.235
Welfare	563.279	499.049	504.903	486.215	640.654	853.772	1028.639
Optimal Tariff Only							
subsidy	0	0	0	0	0	0	0
tariff	-102	-41	-165	-245	-244	-35	24
v	5951	6407	6740	6880	7494	8949	10480
w	3769	3891	4281	4439	4839	5359	5975
Q_1	8,290,636	6,547,626	6,141,706	5,673,150	6,930,603	7,920,655	8,189,523
Q_2	1,730,508	1,948,058	2,075,802	2,139,955	2,444,186	2,428,376	2,368,335
Welfare	562.982	498.981	504.797	486.165	640.463	851.969	1023.572
Optimal Subsidy Only							
subsidy	491	277	342	219	447	1338	2085
tariff	100	100	100	100	100	100	100
v	5410	6116	6378	6653	7016	7313	7624
w	4000	4130	4580	4834	5239	5517	6067
Q_1	9,347,531	6,969,203	6,648,589	6,005,004	7,624,480	10,185,093	12,062.194
Q_2	1,432,016	1,755,363	1,758,390	1,786,287	2,010,503	1,967,143	1,789,220
Welfare	563.225	499.027	504.843	486.139	640.546	853.652	1028.451
Status Quo							
subsidy	0	0	0	0	0	0	0
tariff	100	100	100	100	100	100	100
v	5951	6407	6740	6880	7494	8950	10484
w	4000	4130	4580	4834	5239	5518	6069
Q_1	8,341,000	6,581,000	6,206,000	5,756,000	7,020,000	7,952,000	8,205.000
Q_2	1,546,000	1,819,000	1,833,000	1,831,000	2,112,000	2,300,000	2.300.000
Welfare	562.963	498.972	504.765	486.111	640.406	851.961	1023.569

Welfare in $billion

Table 3: Policy Results — With Labor Rent

	1979	1980	1981	1982	1983	1984	1985
Jointly Optimal Policies							
subsidy	1426	1448	1589	1558	1814	2572	3232
tariff	-242	-119	-262	-312	-370	-403	-551
v	4379	4886	5057	5265	5552	5801	6015
w	3609	3898	4172	4362	4691	4925	5258
Q_1	11,904,968	9,104,444	8,745,164	7,924,114	10,034,817	13,310,974	15,698,210
Q_2	1,468,333	1,643,050	1,752,542	1,812,965	2,066,796	2,029,964	1,948,651
Welfare	573.809	508.592	514.583	495.348	652.872	870.733	1049.542
Optimal Tariff Only							
subsidy	0	0	0	0	0	0	0
tariff	180	290	180	110	135	351	405
v	5951	6407	6740	6880	7494	8951	10490
w	4091	4331	4670	4845	5280	5813	6447
Q_1	8,359,537	6,622,834	6,224,046	5,758,235	7,028,460	8,006,347	8,263,118
Q_2	1,481,012	1,664,472	1,768,063	1,823,068	2,082,063	2,086,968	2,053,546
Welfare	571.307	506.883	512.661	493.749	650.234	863.596	1036.100
Optimal Subsidy Only							
subsidy	1401	1425	1548	1504	1760	2533	3195
tariff	100	100	100	100	100	100	100
v	4407	4910	5100	5321	5610	5849	6098
w	4000	4130	4580	4833	5238	5516	6066
Q_1	11,913,770	9,108,249	8,753,979	7,932,528	10,048,377	13,325,997	15,718,995
Q_2	1,211,527	1,478,861	1,480,877	1,509,647	1,694,871	1,647,189	1,492,444
Welfare	573.764	508.574	514.533	495.285	652.783	870.634	1049.387
Status Quo							
subsidy	0	0	0	0	0	0	0
tariff	100	100	100	100	100	100	100
v	5951	6407	6740	6880	7494	8950	10484
w	4000	4130	4580	4834	5239	5518	6069
Q_1	8,341,000	6,581,000	6,206,000	5,756,000	7,020,000	7,952,000	8,205,000
Q_2	1,546,000	1,819,000	1,833,000	1,831,000	2,112,000	2,300,000	2,300,000
Welfare	571.304	506.869	512.659	493.749	650.234	863.571	1036.066

Welfare in $billion

Table 4: Market Behavior

	1979	1980	1981	1982	1983	1984	1985
β	10.574	9.813	10.076	9.876	12.681	16.144	18.978
σ_x	1.255	1.255	1.274	1.306	1.308	1.282	1.270
Elasticities of Demand							
$\epsilon^{ii}(x,x)$	1.231	1.246	1.263	1.287	1.285	1.262	1.251
$\epsilon^{ij}(x,x)$	0.025	0.009	0.011	0.019	0.023	0.020	0.019
$\epsilon^{ii}(y,y)$	2.728	2.718	2.727	2.726	2.734	2.745	2.744
$\epsilon^{ij}(y,y)$	0.272	0.282	0.273	0.274	0.266	0.255	0.256
$\epsilon^{ij}(x,y)$	0.025	0.034	0.036	0.039	0.036	0.031	0.029
$\epsilon^{ij}(y,x)$	0.356	0.368	0.357	0.334	0.329	0.332	0.335
Cross-Elasticities of Demand							
$L(Q_1,v)$	1.200	1.236	1.250	1.264	1.256	1.236	1.226
$L(Q_1,w)$	0.100	0.136	0.156	0.164	0.156	0.136	0.126
$L(Q_2,w)$	1.900	1.864	1.850	1.836	1.844	1.864	1.874
$L(Q_2,v)$	0.800	0.764	0.750	0.736	0.744	0.764	0.774

$\beta : \times 10^{10}$

Table 5: Calibration using Demand Cross-Elasticities
$L(Q_1, v) = 1.247$ and $L(Q_2, w) = 1.636$

	1979	1980	1981	1982	1983	1984	1985
ϵ	1.192	1.163	1.149	1.135	1.143	1.163	1.172
σ	1.691	1.720	1.734	1.748	1.740	1.720	1.711
σ_x	1.197	1.207	1.225	1.256	1.255	1.230	1.218
γ	-9.581	-19.643	-16.595	-26.945	-13.919	-4.190	-2.424
γ^*	-5.338	-15.295	-6.183	-5.207	-4.403	-3.962	-2.440
subsidy	517	306	391	283	511	1381	2122
tariff	-276	-135	-292	-345	-411	-453	-622
Welfare	296.37	307.68	339.02	360.52	447.98	531.03	611.49
$\epsilon^{ii}(x,x)$	1.219	1.226	1.236	1.252	1.251	1.237	1.230
$\epsilon^{ij}(x,x)$	-0.022	-0.019	-0.010	0.004	0.004	-0.007	-0.013
$\epsilon^{ii}(y,y)$	2.662	2.662	2.676	2.679	2.686	2.694	2.690
$\epsilon^{ij}(y,y)$	0.338	0.338	0.324	0.321	0.314	0.306	0.310
$\epsilon^{ij}(x,y)$	0.014	0.021	0.023	0.026	0.024	0.019	0.017
$\epsilon^{ij}(y,x)$	0.197	0.228	0.232	0.228	0.218	0.206	0.201
$L(Q_1,w)$	0.055	0.084	0.098	0.112	0.104	0.084	0.075
$L(Q_2,v)$	0.444	0.473	0.487	0.501	0.493	0.473	0.464

Welfare in $billion

Table 6: Firm Behavior

	1979	1980	1981	1982	1983	1984	1985
γ	-9.57	-19.62	-16.57	-29.91	-13.89	-4.17	-2.40
γ^*	-5.27	-15.24	-6.13	-5.16	-4.36	-3.91	-2.39
$\gamma^{11} = \gamma^{12}$	-53.42	-88.73	-70.94	-104.79	-55.02	-16.88	-9.93
$\gamma^{21} = \gamma^{22}$	-3.86	-11.31	-4.42	-3.67	-3.09	-2.89	-1.81
$\gamma^{11} = \gamma^{22}$	41.12	36.73	37.67	64.61	33.87	6.01	3.15
$\gamma^{12} = \gamma 21$	-73.06	-94.68	-76.91	-121.30	-66.40	-19.56	-11.44
v	5951	6407	6740	6880	7494	8950	10484
w	4000	4130	4580	4834	5239	5518	6069
v_B	23895	25257	25111	24918	26626	29913	32472
w_B	5567	6220	6469	6723	7152	7425	7735
v_C	26553	28434	28178	27698	29494	33133	35958
w_C	5857	6591	6861	7142	7574	7813	8123
γ^{11}	-0.0001	-0.0141	-0.0141	-0.0068	-0.0026	-0.0006	0.0007
γ^{12}	0.0365	0.0389	0.0393	0.0392	0.0387	0.0367	0.0359
γ^{21}	0.3139	0.3551	0.3513	0.3455	0.3285	0.3093	0.3033
γ^{22}	0.1717	0.1835	0.1826	0.1850	0.1788	0.1664	0.1636
γ_C	0.0410	0.0510	0.0532	0.0523	0.0496	0.0446	0.0419
γ_C^*	0.2064	0.2287	0.2336	0.2395	0.2311	0.2108	0.2034

Table 7: Comparison of Models

	1979	1980	1981	1982	1983	1984	1985
NO LABOR RENT							
CES Model							
subsidy	528	312	404	299	528	1397	2141
tariff	-245	-122	-267	-318	-377	-410	-559
Dixit's Linear Model							
subsidy	611	325	406	257	538	2012	3784
tariff	408	211	439	520	604	616	794
Welfare							
W^{CES}	563.28	499.05	504.90	486.21	640.65	853.77	1028.64
W^{D}	563.09	499.00	504.70	485.95	640.26	852.62	1019.20
W^{MFN}	562.96	498.97	504.76	486.11	640.41	851.96	1023.57
WITH LABOR RENT							
CES Model							
subsidy	1426	1448	1589	1558	1814	2572	3232
tariff	-242	-119	-262	-312	-370	-403	-551
Dixit's Linear Model							
subsidy	1712	1590	1760	1640	2044	3775	5771
tariff	357	181	381	119	529	542	708
Welfare							
W^{CES}	573.81	508.59	514.58	495.35	652.87	870.73	1049.54
W^{D}	573.46	508.52	514.37	495.26	652.46	865.52	985.99
W^{MFN}	571.30	506.87	512.66	493.75	650.23	863.57	1036.07

Welfare in $billion

Table 8: Effect of VER's in 1983 on Firms' Conjectures

	MFN Actual CV's	MFN Modified CV's	Tariff Rate Quota	Optimal Actual CV's	Optimal Modified CV's
NO LABOR RENT					
γ	-13.885	-27.770	-27.770	-13.885	-27.770
γ^*	-4.355	-8.710	-8.710	-4.355	-8.710
v	7494	7249	7250	6929	6954
w	5239	4931	5170	4684	4570
subsidy	0	0	0	528	285
tariff	100	100	318	-377	-229
Q_1	7,020,000	7,249,339	7,303,303	7,611,905	7,546,347
Q_2	2,112,000	2,304,043	2,111,708	2,449,221	2,568,974
Welfare	640.406	641.189	641.117	640.6549	641.277
LABOR RENT = \$1400					
γ	-13.885	-27.770	-27.770	-13.885	-27.770
γ^*	-4.355	-8.710	-8.710	-4.355	-8.710
v	7494	7249	7250	5552	5570
w	5239	4931	5170	4691	4576
subsidy	0	0	0	1814	1622
tariff	100	100	318	-370	-224
Q_1	7,020,000	7,249,339	7,303,303	10,034,817	9,962,263
Q_2	2,112,000	2,304,043	2,111,708	2,066,796	2,170,450
Welfare	650.2346	651.338	651.342	652.872	653.398

Welfare in \$billion

Table 9: Cost Sensitivity
1979, Labor Rent = 0

US Cost		Japan Cost		
		3000	3400	3600
5000	γ	-5.027	-5.027	-5.027
	γ^*	-1.717	-5.272	-10.606
	subsidy	842	822	812
	tariff	-408	-244	-151
	Welfare	567.280	567.189	567.162
5400	γ	-9.570	-9.570	-9.570
	γ^*	-1.717	-5.272	-10.606
	subsidy	553	528	516
	tariff	-410	-245	-152
	Welfare	563.376	563.279	563.250
5600	γ	-15.724	-15.724	-15.724
	γ^*	-1.717	- 5.272	-10.606
	subsidy	389	361	348
	tariff	-411	-246	-152
	Welfare	561.552	561.451	561.422

Welfare in $billion

Table 10: Sensitivity to ϵ and σ
1979, No Labor Rent

Elasticity of Demand (ϵ)		Elasticity of Substitution (σ)		
		1.5	2.0	3.0
1.05	β	42.010	46.650	49.159
	γ	-9.670	-9.590	-9.471
	γ^*	-5.384	-5.274	-5.053
	subsidy	519	531	541
	tariff	-308	-247	-182
	Welfare	1121.482	1121.480	1121.484
	$\epsilon^{ij}(x,x)$	0.024	0.044	0.050
	$\epsilon^{ij}(y,y)$	0.384	0.274	0.053
1.1	β	8.657	10.574	11.686
	γ	-9.651	-9.570	-9.452
	γ^*	-5.382	-5.272	-5.052
	subsidy	517	528	538
	tariff	-307	-245	-180
	Welfare	563.281	563.279	563.282
	$\epsilon^{ij}(x,x)$	0.004	0.025	0.031
	$\epsilon^{ij}(y,y)$	0.382	0.272	0.052
1.3	β	0.167	0.278	0.359
	γ	-9.572	-9.491	-9.372
	γ^*	-5.377	-5.267	-5.047
	subsidy	507	518	529
	tariff	-300	-239	-174
	Welfare	191.184	191.182	191.186
	$\epsilon^{ij}(x,x)$	-0.075	-0.054	-0.048
	$\epsilon^{ij}(y,y)$	0.377	0.267	0.047
1.5	β	N/A	0.0265	0.0382
	γ		-9.412	-9.293
	γ^*		-5.261	-5.041
	subsidy		511	522
	tariff		-234	-169
	Welfare		116.800	116.803
	$\epsilon^{ij}(x,x)$		-0.133	-0.127
	$\epsilon^{ij}(y,y)$		0.261	0.041

Welfare in \$billion
$\beta : \times 10^{10}$

Table 11: Sensitivity to σ_y

1979

	σ_y 1.5	2.1	3.0	5.0	50.0
σ_x	1.154	1.216	1.255	1.287	1.323
β	8.741	10.039	10.574	10.915	11.238
γ	-9.626	-9.591	-9.570	-9.552	-9.532
γ^*	-6.401	5.949	-5.272	-3.767	30.094
$\epsilon^{ii}(x,x)$	1.174	1.209	1.231	1.248	1.268
$\epsilon^{ij}(x,x)$	-0.020	0.007	0.025	0.039	0.055
$\epsilon^{ii}(y,y)$	1.599	2.051	2.728	4.233	38.094
$\epsilon^{ij}(y,y)$	-0.099	0.049	0.272	0.767	11.906
$\epsilon^{ij}(x,y)$	0.025	0.025	0.025	0.025	0.025
$\epsilon^{ij}(y,x)$	0.356	0.356	0.356	0.356	0.356

$\beta : \times 10^{10}$